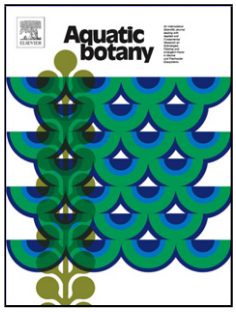

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The conservation of aquatic vascular plants in Asian Russia

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Highlights

- We studied protected aquatic vascular plants of Asian Russia.
- 96 of the 246 species are listed as threatened in the regional Red Data Books.
- Habitat degradation under human impact and climate change a threat for most species.
- The main conservation action needed are protection of natural habitats.
- There is a need to resolve taxonomic questions which are obstructing conservation.

We present current information on the conservation of aquatic vascular plants in West and East Siberia and the Russian Far East. This includes the region from the Ural Mountains in the west to the eastern seaboard of Russia from Kamchatka and Chukotka in the north to Vladivostok in the south, including Sakhalin, the Kuril and Commander Islands. A list of aquatic vascular plant species occurring in the region is presented with an indication of their conservation status derived from regional Red Data Books, combined with population trend data from the literature, as well as field observations made by the authors. The region as a whole supports a total of 246 aquatic plant species, of which 96 are listed as threatened in regional Red Lists. The main threats to these species are habitat degradation, eutrophication and pollution of water bodies as a consequence of human activity and climate change. Many species which are specialized, relict or endemic, and others occurring here on the edge of their range, are vulnerable because of these factors. The main conservation action needed includes protection of natural habitats, establishment of monitoring protocols for the most severely threatened species and research into the autecology of threatened species. There is also a need to resolve taxonomic questions obstructing conservation.

Key words: aquatic vascular plants, Asian Russia, conservation, population trend, Red Data Books, threats.

1. Introduction

Despite the fact that aquatic vascular plants represent only about 1% of total floristic diversity (Chambers *et al*., 2008), they are extremely important for the function of freshwater ecosystems, as primary producers, as habitat for other organisms, in erosion control and in their role in water purification (Cook, 1996; Bornette & Puijalon, 2009). Changes resulting from human activities, such as climate change, pollution and eutrophication of water bodies, are modifying freshwater ecosystems at a very fast rate (Bates *et al*., 2008) and these have knock-on effects on biodiversity, including aquatic vascular plants (Alahuhta *et al*., 2011; Bilz *et al*., 2011).

Due to the ameliorating effects of aquatic habitats in temperate latitudes, aquatic vascular plants show low species diversity, low level of endemism and wide geographical ranges for many species (Santamaría, 2002; Chambers *et al*., 2008; Bilz *et al*., 2011) compared to terrestrial plants. For these reasons, Red Lists typically include relatively few aquatic vascular plant species. For example, in Europe only 26 of 393 species assessed were classed as threatened (Bilz *et al*., 2011) using the IUCN criteria (IUCN, 2012), while 274 species were classed as Least Concern (LC). The Russian Red Lists show a similar pattern, 16 aquatic vascular plant species are included in the federal List (Red Data Book, 2008) and one to 25 in regional Lists (OOPT Rossii, 2018). However the diversity of aquatic vascular plants in Russia is still not precisely known, especially in Asian Russia which covers 13 million km^2 and occupies 3/4 of the territory of Russia.

Publication of "Aquatic plants of Russia and adjacent states" (Belavskaya, 1994) and "The flora of water bodies of Russia" (Lisitsyna, Papchenkov, 2000) represented a significant development in research into aquatic vascular plants in Russia. However, for most of the country, the data presented were derived through compilation of publications known at that time, rather than original surveys. Similarly, Raspopov *et al*. (2011) in the attempt of comparative analysis of aquatic flora of Russia and the world provide the number of taxa for the country and its large regions: Russia: 344 species, European Russia: 240 species, West Siberia: 156 species, East Siberia: 157 species and the Far East: 195 species, but these data were also obtained mainly through published floristic and taxonomic data compilation rather than original and critical investigations, particularly with regard to Asian Russia. We suppose that up to 1/3 of the presented list needs revision.

Since 2012, three of the authors have been carrying out research into aquatic vascular plants in Asian Russia to complement the data presented in these and other publications, particularly the poorly studied areas of Siberia and the Far East (Bobrov *et al*., 2014, 2017, 2018; Bobrov & Mochalova, 2014, 2017; Volkova *et al*., 2017, 2018 etc.). This research suggests that estimates of the diversity of aquatic vascular plants in these regions should be revised as follows: Russia: 279 species and 45 hybrids, European Russia: 198 species and 37 hybrids, Asian Russia: 246 species and 27 hybrids, West Siberia: 165 species and 10 hybrids, East Siberia: 163 species and 15 hybrids, the Far East: 188 species and 17 hybrids (Bobrov & Mochalova, 2017; own data, unpubl.).

The history of preparation of regional Red Data Books in Russia in relation to its current borders began with the publication of the first edition of the Red Data Book of the Russian Federation (Red Data Book, 2008; Geltman, 2017). Since then a lot of work has been done, and each of the regions of Russia now has an official edition of the Red Data Book (OOPT Rossii, 2018; Table 1). Each 10–15 years the regional Books should be revised and reissued, therefore many regions already have second or third editions, which allow to analyse trends.

Accurate information on taxonomic diversity is necessary to inform work on other environmental issues, such as biodiversity research at different levels, ecosystem research, bioindication and conservation. However, the level of information on aquatic vascular plants available in different regions of Russia has been very variable, ranging from fairly complete information for parts of European Russia, to areas where data are fragmentary or missing in parts of Asian Russia, which affects the selection of protected aquatic vascular species in the Red Lists.

Our studies of aquatic vascular plants in Russia have enabled us to fill in gaps in data and as a result revise lists of the species included in regional Red Data Books. Our research into aquatic vascular plants in Russia has included a particular focus on rare species, with the aim to analyse the composition of species included in regional Red Data Books, to assess the reasons for their inclusion, to assess conservation status, to analyse population trends, to identify the main conservation actions needed and to propose revisions to regional Red Data Books.

2. Material and methods

This article treats the conservation of aquatic vascular plants occurring in fresh and brackish waters. In this context, the term aquatic plants refers to obligate aquatics, emergent and marginal vascular herbaceous plants, included those growing in the drying littoral zone of water bodies and watercourses and in temporary water bodies, following generally definitions given by Cook (1996) and Chambers *et al*. (2008). Plants mainly occurring in marshes, bogs and wetlands (*Calamagrostis* spp., *Carex* spp., *Eriophorum* spp. etc.) are excluded.

Information on the composition of protected aquatic plants, their distribution, population status, populations trends and major threats to the species was obtained from regional Red Data Books (Table 1), including updates (to October 2018) published in the regional government decrees (OOPT Rossii, 2018), from regional floras (e.g. Arctic flora..., 1960–1987; Vascular plants..., 1985–1996; Flora of Siberia, 1987–2003; Conspectus..., 2012), as well as articles and unpublished data. Additionally we revised the diversity, distribution and ecology of aquatic vascular plants and particularly of rare and protected species through fieldwork in Yakutia (eastern, central and western parts, 2014, 2015), Magadan Region (all territory, 2012–2018), Kamchatka (southern half, 2013), Chukotka (eastern, western parts and the Middle Anadyr valley, 2017, 2018), Amur Region (Middle Amur valley, 2016), Khabarovsk (Lower Amur valley, 2016) and Primorskii Territories (Khanka Lake and southern part, 2016) where aquatic plants were poorly or not studied or represented by many complicated and questionable taxa for evaluation of data presented in regional Red Lists. Specimens of rare and protected aquatic vascular plants in the following herbaria IBIW, LE, MAG, MHA, MW, NS, NSK, SASY, TK, VLA were reviewed to support some records, clarify taxonomic affiliation and obtain additional information on their distribution and ecological preferences.

The conservation status of some species varied across regional Red Data Books of Asian Russia (Table 1) and were therefore analysed to bring them into alignment with the rankings found in the Red Data Book of the Russian Federation (2008). The Russian categories are given below with the respective IUCN categories (IUCN, 2012).

0 – Possibly extinct. Taxa formerly known from the territory of Russia, but not recorded since 1975, although the possibility that they persist cannot be excluded. Comparable with the category Extinct (EX).

1 – Endangered. Taxa whose numbers have decreased to a critical level or the number of known localities has decreased so much that in the near future they may become extinct. Comparable with the category Critically Endangered (CR).

2 – Declining. Taxa which are undergoing continued decline and which could become endangered if the rate of decline increases. Encompasses part of Endangered (EN) and Vulnerable (VU), includes:

a) taxa subject to a population decline due to changes in conditions or habitat destruction.

b) taxa subject to a population decline due to over-exploitation by man and which could be stabilized by special protection measures (such as medicinal, food, decorative and other plants).

3 – Rare. Taxa, which occur at naturally low population levels, in a limited area or scattered over large areas, for which survival is dependent on the adoption of special protection measures. Falls between Vulnerable (VU) and Near Threatened (NT), includes taxa:

a) which are locally endemic.

b) which occur over a wide geographical area, within which there are only a few scattered populations.

c) with a narrow ecological range associated with specific conditions (such as outcrops of limestone or other bedrock, saline soils, littoral habitats).

d) which are abundant over a large area but extralimital within Russia.

e) with a limited range, part of which is located in the territory of Russia.

4 – Undefined. Taxa which probably belong to one of the previous categories, but information is inadequate or they do not fully meet the criteria of other categories. Comparable with Data Deficient (DD).

5 – Recoverable and regenerative. Taxa which were formerly declining but are now stable or recovering either due to natural causes or to conservation, to the point where they are no longer classed as threatened. In practice, this category is not applied in regional Red Books, but the species are included in a special supplement with an additional list of species requiring attention and observation, without indicating the conservation status and population trends. Included within Least Concern (LC). Species of this category are not considered in the present paper.

Population trends were estimated comparing information on population statuses presented in descriptions for each species in different editions of regional Red Data Books (Table 1) and reports about monitoring of populations of protected species (OOPT Rossii, 2018) and our own data (see Appendix S1 in Supporting information).

Plant names follow Conspectus of the flora of Asian Russia (2012) like in regional Red Data Books of Asian Russia and associated nature protection official documents, also follow our own knowledge (i.e. *Callitriche*, *Ceratophyllum*, *Elatine*, *Eleocharis*, *Najas*, *Trapa*, *Zannichellia*), generally they conform to The Plant List (2013+). For some species we provide necessary taxonomic information such as synonymy (e.g. previously used but not correct name in present) and belonging to species aggregates (e.g. "s.l.", the species from which a taxon was recognized) or intraspecific taxa (e.g. "subsp.", a category which is rarely used in Russian botany).

3. Results

3.1. Number of protected aquatic vascular species

Of a total of 246 species, 96 species of 48 genera and 33 families are protected in the regions of the Asian part of Russia (Table 2, see Appendix S1 in Supporting information). Of these hydrophytes (obligate aquatic plants, 60 species) represent the most abundant ecological group, with smaller numbers of helophytes (semiaquatic or amphibious plants, 17 species), and hygrohelophytes (littoral and riparian species, 19 species).

The largest number of protected species is listed in the Far East (59 species), which also supports the greatest diversity of aquatic plants (188 species) (Table 2, 3). Thermophilic tropical plants (such as *Brasenia schreberi*, *Euriale ferox*, *Nelumbo komarovii* and *Trapella sinensis*) and Asian species (such as *Caldesia reniformis*, *Nuphar japonica*, *Torreyochloa natans*, *Potamogeton maackianus*, *P. wrightii* and *Schoenoplectus nipponicus*), as well as some amphi-Pacific and mainly North American plants (such as *Isoëtes maritima*, *Myriophyllum ussuriense* and *Schoenoplectus acutus*) are restricted to this region. In West Siberia, there is a large number of protected plants, 46 species, from a total of 165 species. The mainly European species (such as *Elatine alsinastrum*, *Marsilea strigosa*, *Myriophyllum spicatum*, *Najas minor*, *Potamogeton rutilus*, *P. sarmaticus*, *Ranunculus polyphyllus* and *Ruppia drepanensis*) and Central Asian forms (such as *Schoenoplectiella lateriflora* and *Schoenoplectus ehrenbergii*) only occur in West Siberia. East Siberia supports the lowest number of protected aquatic species, 28, from 163 species in total. Only in regions of East Siberia a few western species occur on the edge of their range (such as *Hydrocharis morsus-ranae* and *Sagittaria sagittifolia*), and some ecologically specialised species are rare (such as littoral *Eleocharis parvula* and spring *Montia fontana*).

The number of aquatic plants which are protected in the different regions varies from three to 20 (Table 3, Figure 1). Only three species are protected in the Yamal-Nenets Autonomous Area, four in the Republics of Altai, Khakassia, Tuva and the Sakhalin Region and five in the Khanty-Mansi Autonomous Area – Yugra and Sverdlovsk Region. The highest numbers of protected species are in the Irkutsk Region and Khabarovsk Territory (20 species each), Primorskii Territory

(19 species) and Amur Region (17 species). In the other regions the number of protected species varies from six to 14 species.

3.2. Reasons for inclusion in regional Red Data Books

Populations of aquatic plant species which are on the edge of their range are often less resilient than those in the centre of the range. The large extent of Asian Russia both from west to east and from north to south represents the limits of the distribution of many species of aquatic plants. Thus, some species of predominantly European distribution (such as *Marsilea strigosa*, *Isoëtes lacustris*, *Elatine alsinastrum*, *Potamogeton rutilus*, *P. sarmaticus* and *Ranunculus polyphyllus*) sporadically occur in water bodies of the Trans-Urals and West Siberia; amphi-Pacific or mainly North American plants (such as *Isoëtes maritima*, *Myriophyllum ussuriense* and *Schoenoplectus acutus*) occur at the eastern edge of their range in the Russian Far East; subarctic plants (such as *Callitriche subanceps*) penetrate far to the north; and tropical Asian species (such as *Brasenia schreberi*, *Euryale ferox*, *Nymphoides coreana* and *Trapella sinensis*) occur in the extreme southeast of their range predominantly in Amur and Primorie areas. *Brasenia schreberi*, *Euryale ferox* and *Nelumbo komarovii* may be considered to be relicts. The fact that species are at the limits of their global range is the most frequent reason for their inclusion in regional Red Data Books of Asian Russia and the 61 species represent 64% of the list (Table 2).

The second largest group of aquatic plants included in regional Red Lists involves species which either occur at naturally low population levels or in populations which are scattered across their entire range, mostly due to narrow ecological specialization (30 species) (Table 2). Species which have a wide distribution but are rare throughout their range includes some such as species of the Nymphaeaceae and some others which are quite common but sensitive to disturbance, and species characteristic of clear, unpolluted oligotrophic lakes (such as *Isoëtes* spp., *Najas flexilis*, *N. tenuissima*, *Potamogeton rutilus*, *Sparganium angustifolium* and *Subularia aquatica*), littoral habitats (such as *Coleanthus subtilis*, *Elatine* spp. and *Ranunculus reptans*), springs (such as *Crassula aquatica* and *Montia fontana*) and species which occur in brackish water (such as *Bolboschoenus planiculmis*, *Eleocharis parvula*, *Najas marina* group, *Ruppia* spp. and *Zannichellia palustris*).

In Asian Russia only five species can be recognized as local endemics, all of which occur in the Far East (*Eleocharis starczenkoae* and *Nuphar japonica* in Middle Amur, *Nelumbo komarovii* and *Trapa maximowiczii* in Middle Amur and south of the Primorskii Territory, and *Zannichellia komarovii* in Kamchatka) (Table 2).

3.3. Conservation status of protected aquatic vascular species

The conservation status assigned within the regions of Asian Russia varies greatly (Table 2, see Appendix S1 in Supporting information). It is typically higher than those in the IUCN Red List (IUCN, 2018) but sometimes lower than in the Red Data Book of Russia (2008). The IUCN categories EN and NT include only two species and the remainder are classed as LC. In the Red Data Book of Russia (2008) eight species protected in Asian Russia are classed as the category 1 Endangered (50% of the total number), three species as the category 2 Declining and five species as the category 3 Rare.

3.4. Population trends of protected aquatic vascular species

The proportion of species that are declining is lowest in East Siberia (25%), while in West Siberia and the Far East 37% are declining each (Table 2, Figure 2). The proportion of species with stable populations is lowest in West Siberia (32%) and higher in East Siberia and the Far East (54% and 37% respectively). The proportion of species with an unknown population trend is 21–31%. No species are considered to be increasing.

3.5. The main conservation actions

Data from regional Red Data Books suggest that the main conservation actions needed for aquatic plants are monitoring of known populations and protection of the species through habitat and site protection in protected areas of different categories.

4. Discussion

4.1. Patterns and issues in the number of protected aquatic vascular species

In Asian Russia, 246 species of aquatic plants have been recorded which is roughly half of the 497 species reported from the Palaearctic as a whole (Chambers *et al*., 2008). Despite the huge area occupied by Asian Russia, the number of aquatic plants is relatively low, which may be because much of the area is situated in the north and characterised by cold climate with extensive areas underlain by permafrost (Alisov, 1956). The highest diversity of aquatic plants is typically found in regions with tropical and sub-tropical climate (Chambers *et al*., 2008; Tapia Grimaldo *et al*., 2017), decreasing towards high latitudes (Heino & Toivonen, 2008). At the same time, the human population of warm regions and consequently the human impact on aquatic ecosystems may be higher than in the northern areas.

Among the large geographic areas in Asian Russia, the area with greatest number of aquatic vascular plants differ by the largest number of protected species (the Far East) (Table 3, Figure 1). The same can be expected for separate administrative regions. The regions with the large number of aquatic species occurring on the edge of their geographic range have a large number of protected species. For example, many thermophilic tropical plants occur in the Khabarovsk and Primorie Territories, Amur Region; Pacific and mainly North American plants represented in the Kamchatka Territory and Magadan Region; the ranges of a number of Euro-Siberian and East Asian species end in the Irkutsk Region; scattered populations of some mainly European species are distributed in the Chelyabinsk, Kurgan, Tyumen, Omsk and Novosibirsk Regions. On the other hand, many of these regions have a quite well-studied aquatic floras, which may affect the proportion of protected species recorded.

Low numbers of protected species may also reflect low aquatic plant diversity in a region. For example, the low diversity of the island flora of the Sakhalin Region, or the impoverished aquatic flora of the vast but uniform West Siberian Plain of Yamalo-Nenets Autonomous Area. However, this may also be a direct consequence of a lack or deficiency of data on aquatic plants in certain regions. A small number of protected species of aquatic plants in the island flora of Sakhalin and the northern regions with large areas may be considered normal, but in the regions located to the south, the larger numbers of protected species (e.g. 10–15) should be expected. This is especially true for territories with a limited number of water bodies (for example, the Republics of Altai, Khakassia and Tuva, Trans-Baikal Territory) and regions which combine relatively high human population density with developed industry (the Sverdlovsk and Tomsk Regions, Khanty-Mansi Autonomous Area – Yugra) or agriculture (the Altai Territory), where the risks to aquatic plants are high (Table 3).

Different regional Red Lists employ inconsistent taxonomic approaches, for example, in the Russian Far East, *Nelumbo komarovii* is accepted as a species, but in the Red Data Book of Russia (2008) it is included within *N. nucifera*. The most striking example of such taxonomic issues in the region is the genus *Trapa*, which are annual aquatic plants that show strong fruit polymorphism (Berestenko & Kislov, 2013). This has led to recognition of eight to 11 species in Russia (Tzvelev, 1995; Pshennikova, 2006) and globally a total of 89 names for six recognized species in The Plant List (2013+). In some regions, such as the Jewish Autonomous Region, Khabarovsk and Primorie Territories, a "narrow" taxonomic perspective is applied with one to five local species recognized, while in others such as the Amur Region a single species, *T. natans* s.l. is recognized, and is listed with the category 2 Declining in the Red Data Book. The situation is equally complex in Europe

(Bilz *et al*., 2011). The taxonomic status of *Callitriche subanceps* which falls within the *C. palustris* group is still unclear (Lansdown, 2006; Bobrov *et al*., 2014), as to whether it is a distinct species or variety of *C. palustris*. Difficulties with the taxonomic interpretation of species and the definition of their conservation status also affect other groups of aquatic and semiaquatic plants, such as *Juncus* and *Potamogeton* (Kirschner & Kaplan, 2002). Different taxonomic approaches represent a major constraint on the use of regional Red Data Books for practical conservation.

4.2. Reasons for inclusion in regional Red Data Books and the main threats

The reasons for inclusion in regional Red Data Books are occurrence on the edge of their global range, rarity throughout their range mainly due to ecological specialization or local endemism.

Within the group of species occurring on the edge of their global range, the species which may be considered to be relicts of Tertiary flora, such as *Brasenia schreberi*, *Euryale ferox* and *Nelumbo komarovii*, are highly threatened. Natural populations of these species are particularly vulnerable, because some of them are common in cultivation (for example, *Nelumbo komarovii*) and there is no control on their dispersal by people. The genetic integrity of wild populations is therefore threatened by potential hybridization with escaped cultivars.

Another small group of species which are subject to obligatory protection at regional and state levels are local endemics. Aquatic plants typically show quite a low level of endemism (Cook, 1985), and only 28% of aquatics occurring in the Palearctic are considered to be endemic (Chambers *et al*., 2008). Most endemic species may be considered neo-endemics because they originated since the last glaciation, as has been suggested for the aquatic flora of Europe and the Mediterranean where 75% of endemics originated during or after the Pleistocene (Cook, 1985). In Asian Russia, endemic aquatic vascular plants are represented by the Far East species: *Eleocharis starczenkoae*, *Nelumbo komarovii*, *Trapa maximowiczii* and *Zannichellia komarovii*. There were no catastrophic climatic changes in the Pleistocene in the Far East, and it is obvious that many species found there have survived from a much earlier time. There are a few endemics, because similar ecological conditions in aquatic environments across the vast territory of Asian Russia allow many aquatic species to be widespread (Les *et al*., 2003). Successful long-distance dispersal of aquatic plants has been facilitated by broader ecological tolerances and the plastic responses of many aquatic plants, their enhanced survival due to clonal growth and the abundance of easily dislodged propagules (Les *et al*., 2003).

The main threats which affect populations of protected aquatic species in the regions of Asian Russia are the increase in the trophic status of water bodies, pollution by industrial and domestic sewage (National atlas of Russia, 2008), excessive recreational use and changes in the hydrological regime of water bodies, mainly linked to construction of dams, roads, pipelines and similar infrastructure (Shiklomanov, 2008). Generally, these are the same as threats reported for Europe, where they have a more significant effect (Bilz *et al*., 2011). In West Siberia industrial factors are mainly a consequence of oil and gas production, in East Siberia of mining of non-ferrous metals and in the Far East of mining of gold, diamonds and complex ores (National atlas of Russia, 2008).

There has been very little research into the potential impacts of climate change and associated phenomena, particularly thawing of the permafrost (Tishkov, 2012; Meltofte, 2013) on aquatic plants, in spite of the fact that they may be very significant for aquatic ecosystems at high latitudes where the most important are the eutrophication and changing of hydrochemical parameters of water bodies (Vonk *et al*., 2015). Another notable effect of climate change is the range expansion of both native widespread species and non-native species northward, which has already been recorded, and many southern species now occurring north of their conventional ranges (Bobrov & Mochalova, 2014, 2017).

At the southern edge of its range and in polluted or eutrophic conditions, populations of northern oligotrophic *Sparganium angustifolium* and *S. gramineum* Georgi may be replaced by hybrids with southern eurytopic *S. emersum* Rehm. which is spreading northwards and in disturbed habitats (Cook & Nicholls, 1986; Mäemets, 2016). This situation was observed in Yakutia (Bobrov & Mochalova, 2017) and north of the Kamchatka Territory (own data, unpubl.). *Hippuris tetraphylla* L. f., a species characteristic of brackish, coastal Arctic water bodies is disappearing from the coastal waters of Taimyr, Yakutia and Chukotka. In places, it is being replaced by *H.* × *lanceolata* Retz., its hybrid with the widespread, southern *H. vulgaris* L., possibly due to the declining salinity of water in marsh ecosystems caused by dilution due to increasing fresh water run-off (Tzvelev, 1980; own data, unpubl.).

The alien *Egeria densa* Planch. was recently found in the Trans-Urals (Fominykh *et al*., 2016), while *Elodea canadensis* Michx. has expanded its range to the north in West and East Siberia (Sviridenko *et al*., 2013; Bobrov *et al*., 2017). The latter species can be a serious threat to rare and protected species, especially in clear oligotrophic lakes (Mjelde *et al*., 2012).

It is obvious that processes associated with climate change will continue and their effect will only increase. Oligotrophic microthermal and brackish-water aquatic species appear to be the most vulnerable to these processes.

Hybridization may represent an underestimated threat to extralimital and marginal populations. Such populations often show reduced competitive ability and they may be vulnerable to being lost to hybridization with more widespread and tolerant species. In central Europe, for example, more than a half of relict populations of *Nuphar pumila* have been affected by hybridization with *N. lutea* (Arrigo *et al*., 2016), similarly, traces of hybridization have been found in remote populations of *N. japonica* in the Amur River Basin, which is protected in the Khabarovsk Territory (Volkova *et al*., 2018).

4.3. Issues on conservation status of protected aquatic vascular species

Inclusion of a species in a regional Red Data Book is based on its distribution within a region using herbarium and publication data. Determination of the conservation status of a species in a region is based on an assessment of its occurrence and the number of populations. The occurrence is very important, therefore some casual species that are widespread outside the region, but known only from a few localities within the region, are included in the Red Lists. Information on occurrence and distribution of aquatic plants in Asian Russia is very inconsistent making it difficult to develop an objective assessment of the conservation status of some species, and it is certain that some species are significantly overlooked. These include species with a wide distribution but which are rare throughout their range: *Aldrovanda vesiculosa, Coleanthus subtilis, Elatine* spp., *Limosella aquatica, Montia fontana, Ranunculus reptans, Subularia aquatica* and *Zannichellia* spp. Most of these are either small, inconspicuous plants, which are easily missed during surveys, or occur in habitats which are rarely surveyed, such as gravel pits, drainage canals, irrigation canals and silty shallow water. Many of them are ephemeral species that can disappear for several years from a site and then unpredictably re-appear, or are annuals and perennials whose existence depends on the hydrological regime of water bodies (such as species of drying littoral zones of rivers and lakes). Therefore, these species are rarely collected by botanists and are poorly represented in herbarium collections. It is difficult to assess the conservation status for most of these species and they should be classed as the category 4 Undefined, however in regional Red Data Books the conservation status of such species is usually overestimated. For example, *Elatine hydropiper* and *E. triandra* are classed as the category 2 Declining or category 3 Rare in regional Red Data Books of West and East Siberia. Although it may be appropriate to class these species as the category 3 Rare, it is not appropriate to class them as the category 2 Declining, because the occasional disappearance of sub-populations may be temporary rather than representing a true decline. During surveys in the Primorie Territory, *Aldrovanda vesiculosa* was found in high

abundance in former rice paddies, flooded ditches and river mouths around Khanka Lake. While its current conservation status in the regions is "EN" (equal to the category 2), this does not quite correspond to the observed situation of the species.

4.4. Patterns in population trends of protected aquatic vascular species

Trends in the number of protected aquatic species vary considerably depending on the scale of the area involved. In Asian Russia, 49 species are included in the IUCN Red List (2018) (Table 2, Figure 2). Globally, most of the aquatic plants of the region are not considered to be threatened and approximately 1/2 have stable populations, for 1/3 of species there is no data, and 1/5 is represented by species that are increasing (Figure 2). Most of the protected species in the region listed in the Red Data Book of Russia are declining (94%). In three geographic regions of Asian Russia, the proportion of species that are declining less, from 1/4 to 1/3 of the total list. Most declining species occur in West Siberia and the Far East, which also supports the highest human population and is characterised by a highly developed industry, including oil and gas production in West Siberia and mining of gold, diamonds and complex ores in the Far East, as well as intensive agriculture on the south of both areas (National atlas of Russia, 2008). It can be caused by degradation of habitats of rare and protected aquatic plants mostly due to decreasing of area and number of valuable aquatic ecosystems, increasing of water pollution and eutrophication. The proportion of species for which there is insufficient information on population trends is quite close in all three geographic regions, mainly involving species which are small, inconspicuous or poorly studied.

4.5. Issues of the main conservation actions

Russian regional Red Data Books include standardized information on each of the species covered which typically consists of information on conservation actions, whether species were included in previous editions of the Red Data Book of the region and adjacent regions, as well as on any monitoring of known populations and representation in different types of protected areas. Few aquatic species have been the subject of conservation action. In Russia, there is a well-developed network of protected areas of different categories (such as state and nature reserves, national parks, nature monuments), significance (local, regional and federal) and area (from <1 km^2 to >18000 km^2). In Asian Russia, there are approximately 4700 such areas (OOPT Rossii, 2018). One element of the protection includes "unique water objects" and thus some protected aquatic plant populations and their habitats are protected. However, there are only a relatively small number of protected areas in the north, and they cover too small areas which are inadequate to ensure the protection of threatened plant species (Andreev, 2009; Tishkov, 2012).

4.6. Revisions to regional Red Lists

Based on the result of this study, we have proposed revisions to the regional Red Lists (Table 4). We suggest to complete the regional Red Lists of 10 regions for one to 11 rare species. On the other hand, we propose to exclude in four regions five species not actually rare, possible alien or of hybrid origin. We recommend to change the conservation status for five species in five regions. There are no additions to the Red List of regions with well-studied aquatic floras. There is not enough information to date for revision of the Lists of three regions. Our recommendations have already been considered in the new editions of Red Data Books of Republic of Sakha (Yakutia) (2017, Table 1) and Kamchatka Territory (2018, Table 1) and used during the preparation of the new edition of Red Data Book of Magadan Region (2019, in press).

4.7. Conclusion

Regional Red Lists of Asian Russia are constantly being revised and refined according to data derived through monitoring of populations of protected species in most of the regions during

the last 20 years. Generally, there is a tendency for the number of protected species of aquatic plants in new editions of regional Red Data Books to increase, due to a combination of an increase in the available information and to negative changes occurring in inland freshwater ecosystems.

The most significant threats to aquatic vascular plants in Asian Russia and protected species in particular that are especially sensitive to changes are water pollution and direct disturbances of aquatic ecosystems, also factors associated with global warming (eutrophication, changing of water chemistry, range expansion of native widespread and non-native species, hybridization). The most threatened species are those which are known only as small populations in a single locality and those which have a high degree of ecological specialisation, particularly those which are dependent upon oligotrophic and brackish waters.

Population trends for many protected aquatic plants in regional Red Lists are still quite formal, because typically only easy to access populations are monitored, while many known but remote populations may be without control for many years, due to the large size of the territories and the lack of research.

The main conservation actions needed includes protection of natural habitats, establishment of monitoring protocols for the most severely threatened species and research into the autecology of threatened species. There is also a need to resolve taxonomic questions obstructing conservation.

Author contributions

All the authors conceived the ideas, EC, AB, OM collected the data, EC, AB analyzed the data and led the writing, all the authors contributed to the manuscript.

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Table 1. List of Red Data Books of the regions in Asian Russia.

Geographic region	Administrative region	Reference	Online access
West Siberia	1. Yamal-Nenets Autonomous Area	*Red Data Book of Yamal-Nenets Autonomous Area*. *Animals, plants, fungi* [*Krasnaya kniga Yamalo-Nenetskogo avtonomnogo okruga*. *Zhivotnye, rasteniya, griby*], 2010. Basco, Ekaterinburg, 308 pp. [in Russian]	http://oopt.aari.ru/ref/99
	2. Khanty-Mansi Autonomous Area – Yugra	*Red Data Book of Khanty-Mansi Autonomous Area – Yugra*. *Animals, plants, fungi* [*Krasnaya kniga Khanty-Mansiiskogo avtonomnogo okruga – Yugry*. *Zhivotnye, rasteniya, griby*]. 2nd edition, 2013. Basco, Ekaterinburg, 460 pp. [in Russian]	http://oopt.aari.ru/ref/736
	3. Sverdlovsk Region	*Red Data Book of Sverdlovsk Region*. *Animals, plants, fungi* [*Krasnaya kniga Sverdlovskoi oblasti*. *Zhivotnye, rasteniya, griby*], 2008. Basco, Ekaterinburg, 254 pp. [in Russian]	https://www.prlib.ru/item/682765
	4. Chelyabinsk Region	*Red Data Book of Chelyabinsk Region*. *Animals, plants, fungi* [*Krasnaya kniga Chelyabinskoi oblasti*. *Zhivotnye, rasteniya, griby*], 2017. Reart, Moscow, 504 pp. [in Russian]	https://www.ipae.uran.ru/sites/default/files/publications/ipae/1217_2017_RedBook_Chelyabinskaya.pdf
	5. Kurgan Region	*Red Data Book of Kurgan Region* [*Krasnaya kniga Kurganskoi oblasti*]. 2nd edition, 2012. Kurgan State Uni., Kurgan, 448 pp. [in Russian]	https://www.ipae.uran.ru/sites/default/files/publications/ipae/0841_2012_RedBook_KurganskayaSm_1.pdf
	6. Tyumen Region	*Red Data Book of Tyumen Region*. *Animals, plants, fungi* [*Krasnaya kniga Tyumenskoi oblasti*. *Zhivotnye, rasteniya, griby*], 2004. Ural Uni., Ekaterinburg, 496 pp. [in Russian] *Red Data Book of Tyumen Region*. *Animals, plants, fungi* [*Krasnaya kniga Tyumenskoi oblasti*. *Zhivotnye, rasteniya, griby*]. 2nd edition, 2019. Ekaterinburg. (in press) [in Russian]	https://www.ipae.uran.ru/sites/default/files/publications/ipae/0874_2004_RedBook_Tyumenskaya.pdf
	7. Omsk Region	*Red Data Book of Omsk Region* [*Krasnaya kniga Omskoi oblasti*]. 2nd edition, 2015. Omsk State Pedagogogical Uni., Omsk, 635 pp. [in Russian]	http://oopt.aari.ru/ref/1716
	8. Tomsk Region	*Red Data Book of Tomsk Region* [*Krasnaya kniga Tomskoi oblasti*]. 2nd edition, 2013. Pechatnaya manufaktura, Tomsk, 504 pp. [in Russian]	http://elib.tomsk.ru/elib/data/2018/2018-3125/2018-3125.pdf
	9. Novosibirsk Region	*Red Data Book of Novosibirsk Region*. *Animals, plants and fungi* [*Krasnaya kniga Novosibirskoi oblasti*. *Zhivotnye, rasteniya i griby*]. 2nd edition, 2008. Arta, Novosibirsk, 527 pp. [in Russian]	https://dproos.nso.ru/sites/dproos.nso.ru/wodby_files/files/wiki/2014/12/redbook_0.zip
	10. Kemerovo Region	*Red Data Book of Kemerovo Region*. *Volume 1*. *Rare and endangered*	http://oopt.aari.ru/ref/358

		species of plants and fungi [*Krasnaya kniga Kemerovskoi oblasti. Tom 1. Redkie i nakhodyashchiesya pod ugrozoi ischeznoveniya vidy rastenii i gribov*]. 2nd edition, 2012. Aziya Print, Kemerovo, 208 pp. [in Russian]	
	11. Altai Territory	*Red Data Book of Altai Territory. Volume 1. Rare and endangered species of plants* [*Krasnaya kniga Altaiskogo kraya. Tom 1. Redkie i nakhodyashchiesya pod ugrozoi ischeznoveniya vidy rastenii*]. 2nd edition, 2016. Altai St. Uni., Barnaul, 290 pp. [in Russian]	http://oopt.aari.ru/ref/1713
	12. Republic of Altai	*Red Data Book of Republic of Altai. Plants* [*Krasnaya kniga Respubliki Altai. Rasteniya*]. 3rd edition, 2017. Gorno-Altaisk St. Uni., Gorno-Altaisk, 267 pp. [in Russian]	http://oopt.aari.ru/ref/2023
East Siberia	13. Krasnoyarsk Territory	*Red Data Book of Krasnoyarsk Territory. Volume 2. Rare and endangered species of wild-growing plants and fungi* [*Krasnaya kniga Krasnoyarskogo kraya. Tom 2. Redkie i nakhodyashchiesya pod ugrozoi ischeznoveniya vidy dikorastushchikh rastenii i gribov*]. 2nd edition, 2012. Sibirian Federal Uni., Krasnoyarsk, 572 pp. [in Russian]	http://oopt.aari.ru/ref/689
	14. Republic of Khakassia	*Red Data Book of Republic of Khakassia. Rare and endangered species of plants and fungi* [*Krasnaya kniga Respubliki Khakasiya. Redkie i ischezayushchie vidy rastenii i gribov*]. 2nd edition, 2012. Nauka, Novosibirsk, 288 pp. [in Russian]	http://oopt.aari.ru/ref/1100
	15. Republic of Tuva	*Red Data Book of Republic of Tuva* [*Krasnaya kniga Respubliki Tuva*]. 2nd edition, 2018. Tuvinskii St. Uni., Kyzyl, 563 pp. [in Russian]	http://oopt.aari.ru/ref/2024
	16. Irkutsk Region	*Red Data Book of Irkutsk Region* [*Krasnaya kniga Irkutskoi oblasti*], 2010. Vremya stranstvii, Irkutsk, 480 pp. [in Russian]	https://www.prlib.ru/item/691635
	17. Republic of Buryatia	*Red Data Book of Republic of Buryatia: rare and endangered species of animals, plants and fungi* [*Krasnaya kniga Respubliki Buryatiya: redkie i nakhodyashchiesya pod ugrozoi ischeznoveniya vidy zhivotnykh, rastenii i gribov*]. 3rd edition, 2013. Buryatian SC SB RAS, Ulan-Ude, 688 pp. [in Russian]	http://oopt.aari.ru/ref/803
	18. Trans-Baikal Territory	*Red Data Book of Trans-Baikal Territory. Plants* [*Krasnaya kniga Zabaikal'skogo kraya. Rasteniya*], 2017. Dom mira, Novosibirsk, 383 pp. [in Russian]	http://oopt.aari.ru/ref/2021
	19. Republic of Sakha (Yakutia)	*Red Data Book of Republic of Sakha (Yakutia). Volume 1: Rare and endangered species of plants and fungi* [*Krasnaya kniga Respubliki Sakha (Yakutiya). Tom 1: Redkie i nakhodyashchiesya pod ugrozoi ischeznoveniya*	https://cloud.mail.ru/public/E5wz/FAfveVTC3

		vidy rastenii i gribov], 2017. Reart, Moscow, 410 pp. [in Russian]	
Far East	20. Chukotka Autonomous Area	*Red Data Book of Chukotka Autonomous Area*. *Volume 2*. *Rare and endangered species of plants* [*Krasnaya kniga Chukotskogo avtonomnogo okruga*. *Tom 2*. *Redkie i nakhodyashchiesya pod ugrozoi ischeznoveniya vidy rastenii*], 2008. Dikii Sever, Magadan, 217 pp. [in Russian]	http://oopt.aari.ru/ref/70
	21. Magadan Region	*Red Data Book of Magadan Region*. *Rare and endangered species of plants and fungi* [*Krasnaya kniga Magadanskoi oblasti*. *Redkie i nakhodyashchiesya pod ugrozoi ischeznoveniya vidy rastenii i gribov*], 2008. Staryi gorod, Magadan, 430 pp. [in Russian] *Red Data Book of Magadan Region*. *Rare and endangered species of plants and fungi* [*Krasnaya kniga Magadanskoi oblasti*. *Redkie i nakhodyashchiesya pod ugrozoi ischeznoveniya vidy rastenii i gribov*]. 2nd edition, 2019. Magadan. (in press) [in Russian]	http://oopt.aari.ru/ref/61
	22. Kamchatka Territory	*Red Data Book of Kamchatka*. *Volume 2*. *Plants*, *fungi*, *thermophilic organisms* [*Krasnaya kniga Kamchatki*. *Tom 2*. *Rasteniya*, *griby i termofilnye organizmy*], 2007. Kamchatka Publishing House, Petropavlovsk-Kamchatskii, 341 pp. [in Russian] *Red Data Book of Kamchatka*. *Volume 2*. *Plants* [*Krasnaya kniga Kamchatki*. *Tom 2*. *Rasteniya*]. 2nd edition, 2018. Kamchatpress, Petropavlovsk-Kamchatskii, 387 pp. [in Russian]	https://minprir.kamgov.ru/document/file/download?id=74714
	23. Khabarovsk Territory	*Red Data Book of Khabarovsk Territory* [*Krasnaya kniga Khabarovskogo kraya*], 2008. Priamurskie vedomosti, Khabarovsk, 632 pp. [in Russian]	http://oopt.aari.ru/ref/98
	24. Amur Region	*Red Data Book of Amur Region: rare and endangered species of animals, plants and fungi* [*Krasnaya kniga Amurskoi oblasti: redkie i nakhodyashchiesya pod ugrozoi ischeznoveniya vidy zhivotnykh, rastenii i gribov*], 2009. Blagoveshchensk State Pedagogogical Uni., Blagoveshchensk, 446 pp. [in Russian]	http://oopt.aari.ru/ref/260
	25. Jewish Autonomous Region	*Red Data Book of Jewish Autonomous Region*. *Rare and endangered species of plants and fungi* [*Krasnaya kniga Evreiskoi avtonomnoi oblasti*. *Redkie i nakhodyashchiesya pod ugrozoi ischeznoveniya vidy rastenii i gribov*], 2006. ARGA, Novosibirsk, 248 pp. [in Russian]	http://oopt.aari.ru/ref/262
	26. Primorie Territory	*Red Data Book of Primorie Territory: Plants*. *Rare and endangered species of plants and fungi* [*Krasnaya kniga Primorskogo kraya: Rasteniya*. *Redkie i nakhodyashchiesya pod ugrozoi ischeznoveniya vidy rastenii i gribov*],	http://redbookpk.ru/index_plants.html

	27. Sakhalin Region	2008. Apelsin, Vladivostok, 688 pp. [in Russian] *Red Data Book of Sakhalin Region. Plants* [*Krasnaya kniga Sakhalinskoi oblasti*. *Rasteniya*], 2005. Sakhalin Printing House, Yuzhno-Sakhalinsk, 348 pp. [in Russian]	http://oopt.aari.ru/ref/79

Table 2. List of protected aquatic vascular plants of geographic regions in Asian Russia with their current conservation status and population trend.

Taxon (accepted in the paper and presented in Red Data Books of Asian Russia)	Name in The Plant List (if different, with comments)	Ecological group	World		Russia		West Siberia		East Siberia		Far East		Main regional criteria
			IUCN category	Population trend	Conservation category	Population trend	No. of regions / Conservation category	Population trend	No. of regions / Conservation category	Population trend	No. of regions / Conservation category	Population trend	
Acorus calamus L.	–	III	LC	i			2/**3**,**4**	s	1/**3**	s			M
Aldrovanda vesiculosa L.	–	I	EN	d	3b	d					4/**1**,**2**	d	M
Alisma bjoerkqvistii Tzvel.	–	II					1/**3**	u					R
Bolboschoenus planiculmis (Fr. Schmidt) Egor.	–	III									2/**2**	u	R
Brasenia schreberi J. F. Gmel.	–	I	LC	s	1	d			1/**1**	d	3/**1**,**2**	d	M
Caldesia reniformis (D. Don) Makino	*C. parnassifolia* (L.) Parl. (s.l.)	II	LC	u	1	d	1/**1**	d			4/**1**,**2**	d	M
Calla palustris L.		III	LC	s			1/**3**	s			2/**2**,**3**	s	M
Callitriche subanceps Petrov	*C. palustris* L. subsp. *subanceps* (Petrov) Kuvaev	I							1/**2**	u			M
Ceratophyllum demersum L.	–	I	LC	s							1/**3**	s	M
C. oryzetorum Kom.	*C. platyacanthum* Cham. subsp. *oryzetorum* (Kom.) Les	I					1/**3**	u					M
Coleanthus subtilis (Tratt.) Seidel ex Roem. et Schult.	–	III	LC	u	1	d	3/**1**–**3**	d			2/**1**–**2**	d	R

Crassula aquatica (L.) Schönland (*Tillaea aquatica* L.)	*C. aquatica* (L.) Schönland	I			3b	s	1/**4**	u	2/**2**,**3**	s	5/**3**,**4**	s	R
Elatine alsinastrum L.	–	I	NT	d			1/**3**	d					R
E. hydropiper L.	–	I					2/**2**,**3**	s	3/**2**,**3**	u			R
E. orthosperma Düben (*E. spathulata* auct. non Gorski)	*E. hydropiper* L. (wrongly synonymized with)	I									2/**3**	s	R
E. triandra Schkuhr	–	I	LC	u			1/**2**	u	1/**2**	u			R
Eleocharis parvula (Roem. et Schult.) Bluff, Nees et Schauer	–	III							1/**4**	u			R
E. starczenkoae A. E. Kozhevn. (*E. tetraquetra* Nees s.l.)	absent	III									1/**1**	d	E
E. tetraquetra Nees	–	III									1/**1**	d	M
E. wichurae Boeckeler	–	III									1/**3**	d	M
Euryale ferox Salisb.	–	I	LC	s	1	d					2/**1**,**2**	d	M
Glyceria notata Chevall.	–	III	LC	s			1/**0**	d	1/**1**	d			M
Hydrilla verticillata (L. f.) Royle	–	I	LC	i			2/**2**,**3**	s					M
Hydrocharis morsus-ranae L.	–	I	LC	s					1/**2**	s			M
Isoëtes asiatica (Makino) Makino	–	I									5/**2**,**3**	s	R
I. echinospora Durieu	–	I	NT	d	2	d	3/**1**,**4**	d	4/**1**,**2**	d			R
I. lacustris L.	–	I			3	d	2/**1**,**2**	d	2/**0**,**2**	d			R
I. maritima Underw.	–	I			2	d					1/**1**	d	M
Limosella aquatica L.	–	III	LC	s							1/**3**	u	M
Lysimachia thyrsiflora L. (*Naumburgia thyrsiflora* (L.) Reichenb.)	*L. thyrsiflora* L.	III									1/**3**	u	M
Myriophyllum spicatum L.	–	I	LC	u			1/**1**	d					M
M. ussuriense (Regel) Maxim.	–	I	LC	u							2/**3**	s	M
Marsilea strigosa Willd.	–	I	EN	d	1	d	1/**3**	d					M
Montia fontana L.	–	I	LC	s					3/**3**	s			R
Najas flexilis (Willd.) Rostk. et W. L. E. Schmidt (*Caulinia flexilis*	–	I	LC	u	2	d	3/**2**–**4**	d	5/**2**,**3**	s	2/**3**	u	R

Willd.)													
N. japonica Nakai (*Caulinia japonica* (Nakai) Nakai)	*N. gracillima* (A. Br. ex Engelm.) Magnus (s.l.)	I									1/**3**	u	M
N. major All.	*N. marina* L. (s.l.)	I					2/**2**,**3**	s					M
N. marina L.	–	I	LC	s			3/**3**,**4**	s					M
N. minor All. (*Caulinia minor* (All.) Coss. et Germ.)	–	I	LC	u			4/**2**,**3**	u					R
N. tenuissima (A. Br. ex Magnus) Magnus (*Caulinia tenuissima* (A. Br. ex Magnus) Tzvel.)	–	I			1	d	1/**4**	u	1/**1**	u	2/**3**	u	R
Nelumbo komarovii Grossh.	*N. nucifera* Gaertn. (s.l.)	I			3	d					4/**1**,**2**	d	E
Nuphar japonica DC.	–	I			1	d					1/**1**	d	E
N. lutea (L.) Smith	–	I	LC	s			3/**3**	s	2/**2**,**3**	s			R
N. pumila (Timm) DC.	–	I	LC	s			8/**3**	s	5/**2**,**3**	s	7/**2**,**3**	s	R
Nymphaea candida J. Presl	–	I					6/**3**	s	5/**1**–**3**	s			R
N. tetragona Georgi	–	I	LC	s			8/**2**,**3**	s	7/**0**–**3**	d	2/**2**,**3**	s	R
Nymphoides coreana (H. Lév.) H. Hara	–	I			1	d					1/**1**	d	M
N. peltata (S. G. Gmel.) O. Kuntze	–	I	LC	s			3/**2**,**3**	u	2/**2**,**3**	s	1/**3**	s	M
Oenanthe javanica (Blume) DC.	–	III									1/**3**	u	M
Ottelia alismoides (L.) Pers.	–	II	LC	u		d*					2/**1**,**2**	d	M
Persicaria amphibia (L.) S. F. Gray	–	I	LC	s							1/**3**	s	M
Potamogeton lucens L.	–	I	LC	s							1/**3**	d	M
P. maackianus A. Benn.	–	I	LC	s					1/**2**	d	1/**3**	s	M
P. perfoliatus L.	–	I	LC	s							1/**3**	s	M
P. rutilus Wolfg.	–	I					2/**1**,**4**	d					R
P. sarmaticus Mäemets	–	I					2/4	u					R
P. wrightii Morong (*P. malainus* auct. non Miq.)	–	I									1/**3**	s	M
Ranunculus gmelinii DC.	–	III	LC	s			1/**3**	s					M
R. lingua L.	–	III	LC	s			1/**3**	s					M
R. natans C. A. Mey.	–	III					1/**3**	u			1/**3**	d	M

R. polyphyllus Waldst. et Kit. ex Willd.	–	I	DD	d			4/**3**	u					M
R. reptans L.	–	III	LC	u			2/**3**	s					R
Ruppia drepanensis Tineo	–	I					1/**3**	d					R
R. maritima L.	–	I	LC	s			3/**1**	d	1/**3**	s	1/**3**	u	R
Sagittaria aginashii Makino	–	II									1/**1**	d	M
S. natans Pall.	–	II									2/**2**,**3**	s	M
S. sagittifolia L.	–	II							2/**2**,**3**	s			M
S. trifolia L.	–	II	LC	s			1/**3**	s	2/**2**–**4**	s			M
Salvinia natans (L.) All.	–	I	LC	i			3/**2**,**3**	u					R
Schoenoplectiella hotarui (Ohwi) J. Jung et H. K. Choi (*Schoenoplectus hotarui* (Ohwi) Holub)	–	II									1/**2**	d	M
S. komarovii (Roshev.) J. Jung et H. K. Choi (*Schoenoplectus komarovii* (Roshev.) Soják)	–	II									1/**3**	d	M
S. lateriflora (J. F. Gmel.) Lye (*Schoenoplectus lateriflorus* (J. F. Gmel.) Lye)	–	II	LC	s			1/**1**	d					M
S. lineolata (Franch. et Savat.) J. Jung et H. K. Choi (*Schoenoplectus lineolatus* (Franch. et Savat.) T. Koyama)	–	II									1/**3**	u	M
Schoenoplectus acutus (Muhl. ex Bigelow) Á. Löve et D. Löve	–	II	LC	u							1/**3**	s	M
S. ehrenbergii (Boeck.) Soják	–	II					1/**1**	d					M
S. nipponicus (Makino) Soják	–	II									1/**3**	u	M
S. tabernaemontani (C. C. Gmel.) Palla	–	II	LC	s			1/**3**	u					M
S. triqueter (L.) Palla	–	II	LC	s							1/**2**	d	M
Sium sisaroideum DC.	–	III	LC	u			2/**3**,**4**	d					M
Sparganium angustifolium Michx.	–	II	LC	s							1/**3**	d	R

Spirodela polyrhiza L.	–	I									1/**3**	s	M
Stuckenia pectinata (L.) Börner (*Potamogeton pectinatus* L.)	–	I	LC	u							1/**3**	s	M
Subularia aquatica L.	–	I	LC	u			3/**2**–**4**	d	3/**2**,**3**	s	2/**3**	s	R
Thacla natans (Pall.) Deyl et Soják	–	III					1/**2**	d	1/**3**	s	1/**3**	s	M
Torreyochloa natans (Kom.) Church	–	III									2/**3**,**4**	s	M
Trapa incisa Siebold et Zucc.	–	I	LC	u							2/**2**	u	M
T. japonica Fler.	–	I									2/**2**	u	M
T. manshurica Fler.	*T. natans* L. (s.l.)	I									3/**3**	u	M
T. maximowiczii Korsh.	*T. incisa* Siebold et Zucc. (s.l.)	I									1/**3**	u	E
T. natans L. s.l.	–	I	LC	u			4/**0**–**3**	d	3/**1**	d	1/**2**	s	R
T. tranzschelii V. Vassil.	*T. natans* L. (s.l.)	I									1/**4**	u	M
Trapella sinensis Oliv.	–	I			3g	d					4/**3**,**4**	d	M
Vallisneria asiatica Miki	*V. natans* (Lour.) H. Hara	I				d*					2/**2**	d	M
Zannichellia komarovii Tzvel.	*Z. palustris* L. (s.l.)	I									1/**3**	s	E
Z. palustris L.	–	I	LC	s			2/**3**,**4**	s	2/**2**,**3**	s			R
Z. pedunculata Reichenb.	*Z. palustris* L. subsp. *pedicellata* (Wahlenb. et Rosén) Hook. f.	I					1/**4**	u	1/**1**	u			M
Total number		96	49		16		46		28		59		

Note. Ecological groups: I – hydrophytes (aquatic), II – helophytes (semiaquatic), III – hygrohelophytes (littoral, riparian); population trend: d – decrease, i – increase, s – stable, u – unknown; the main regional criteria: M – marginal (edge of the range), R – rare (specialists and rare within the range), E – endemic.

Table 3. Regions of Asian Russia, their area, drainage network density and lake percentage, population and numbers of protected aquatic vascular plants.

Geographic region	Administrative region	Area, thousand km^2	Drainage network density, km/km^2 / Lake percentage,%	Human population, thousands	Number of protected species
West Siberia	**1. Yamal-Nenets Autonomous Area**	769.3	0.38 / 5.07	536.0	**3**
	2. Khanty-Mansi Autonomous Area – Yugra	534.8	0.19 / 4.25	1646.1	**5**
	3. Sverdlovsk Region	194.3	0.07 / 0.7	4329.4	**5**
	4. Chelyabinsk Region	88.5	0.2 / 2.95	3502.3	11
	5. Kurgan Region	71.5	0.07 / 3.87	854.1	11
	6. Tyumen Region	160.1	0.2 / 4.43	1477.9	11
	7. Omsk Region	141.1	0.14 / 1.24	1972.7	14
	8. Tomsk Region	**314.4**	**0.3 / 0.68**	**1078.9**	**6**
	9. Novosibirsk Region	177.8	0.16 / 3.2	2779.5	13
	10. Kemerovo Region	95.7	0.8 / 0.18	2708.8	11
	11. Altai Territory	**168.0**	**0.3 / 1.61**	**2365.7**	**7**
	12. Republic of Altai	92.9	0.46 / 0.6	217.0	**4**
Total	12 regions	2808.4	0.27 / 2.4	25650.5	46
East Siberia	13. Krasnoyarsk Territory	2366.8	0.26 / 2.56	2875.3	12
	14. Republic of Khakassia	61.6	0.39 / 1.3	537.7	**4**
	15. Republic of Tuva	168.6	0.43 / 0.8	318.6	**4**
	16. Irkutsk Region	774.8	0.26 / 2.46	2408.9	20
	17. Republic of Buryatia	351.3	0.43 / 6.5	984.1	11
	18. Trans-Baikal Territory	**431.9**	**0.7 / 0.35**	**1079.0**	**6**
	19. Republic of Sakha (Yakutia)	3083.5	0.5 / 2.59	962.8	8
Total	7 regions	7238.5	0.42 / 2.37	9166.4	28
Far East	20. Chukotka Autonomous Area	721.5	1.02 / 1.87	49.8	13
	21. Magadan Region	462.5	0.82 / 0.34	145.6	11
	22. Kamchatka Territory	464.3	0.78 / 0.85	314.7	14
	23. Khabarovsk Territory	787.6	0.7 / 0.59	1333.3	20
	24. Amur Region	361.9	0.51 / 0.82	801.8	17
	25. Jewish Autonomous Region	36.3	0.5 / 0.22	164.2	10
	26. Primorie Territory	164.7	0.86 / 2.01	1923.1	19
	27. Sakhalin Region	**87.1**	**1.07 / 2.76**	**487.4**	**4**
Total	8 regions	3085.9	0.78 / 1.18	5219.9	59

Note. Regions where the number of protected species of aquatic plants is distinctly low are indicated in bold.

Area and population of the regions are given according to: Federal Service for Statistics [Federal'naya sluzhba gosudarstvennoi statistiki]. Available from: http://www.gks.ru (accessed 29 September 2018). Area: http://www.gks.ru/bgd/regl/b17_14p/IssWWW.exe/Stg/d01/01-01.doc

Population: http://www.gks.ru/bgd/regl/b17_14p/IssWWW.exe/Stg/d01/02-01.doc
Drainage network density and lake percentage are given according to: Water of Russia [Voda Rossii]. Available from: http://water-rf.ru/Регионы_России

Table 4. Recommend changes to regional Red Lists.

Geographic and administrative region	Taxon	Recommended status with criterion	Comment
West Siberia			
1. Yamal-Nenets Autonomous Area			data deficient
2. Khanty-Mansi Autonomous Area – Yugra	*Potamogeton sarmaticus* Mäemets	3d	instead 4
3. Sverdlovsk Region	*Isoëtes echinospora* Durieu	2a	
	I. lacustris L.	3c	
	Sparganium glomeratum (Laest.) L. Neum.	3d	
	S. gramineum Georgi	2a	
	Potamogeton rutilus Wolfg. (?)	1	need to clarify
	Najas flexilis (Willd.) Rostk. et W. L. E. Schmidt	2a	
	N. tenuissima (A. Br. ex Magnus) Magnus	2a	
	Zannichellia repens Boenn.	3b	
	Catabrosa aquatica (L.) Beauv.	3c	
	Bolboschoenus planiculmis (Fr. Schmidt) Egor.	3c	
	B. yagara (Ohwi) J. C. Jang et M. Zhan	3d	
	Eleocharis austriaca Hayek	3d	
4. Chelyabinsk Region	*Potamogeton rutilus* Wolfg.	2a	instead 4
5. Kurgan Region	*Alisma bjoerkqvistii* Tzvel.	exclude	critical taxon, possibly hybrid
6. Tyumen Region	*Potamogeton rutilus* Wolfg. (?)	2a	need to clarify
	P. sarmaticus Mäemets	3d	instead 4
7. Omsk Region	*Potamogeton rutilus* Wolfg.	2a	
8. Tomsk Region	*Potamogeton rutilus* Wolfg.	2a	
9. Novosibirsk Region	*Althenia orientalis* (Tzvel.) García-Mur. et Talavera	3a	
	Potamogeton rutilus Wolfg.	2a	
	Schoenoplectiella lateriflora (J. F. Gmel.) Lye	exclude	possibly alien
10. Kemerovo Region			no additions
11. Altai Territory			**no additions**
12. Republic of Altai			data deficient

East Siberia			
13. Krasnoyarsk Territory	*Potamogeton obtusifolius* Mert. et W. D. J. Koch	3b	
	Hippuris tetraphylla L. f.	3c	
	Najas marina L.	3c	
14. Republic of Khakassia	*Ruppia maritima* L.	3c	
	Zannichellia pedunculata Reichenb.	3d	
	Z. repens Boenn.*	3d	
15. Republic of Tuva			data deficient
16. Irkutsk Region			no additions
17. Republic of Buryatia			no additions
18. Trans-Baikal Territory			**no additions**
19. Republic of Sakha (Yakutia)	*Elatine orthosperma* Düben	3b	
	Potamogeton maackianus A. Benn.	3d	
	P. rutilus Wolfg.	2a	
	Hydrilla verticillata (L. f.) Royle	3d	
Far East			
20. Chukotka Autonomous Area	*Ranunculus codyanus* B. Boivin	3c	
	Utricularia stygia Thor	3c	
	Sparganium angustifolium Michx.	exclude	not rare
	Potamogeton perfoliatus L.	exclude	quite common
21. Magadan Region			our corrections were accepted in new edition
22. Kamchatka Territory			our corrections were accepted in new edition
23. Khabarovsk Territory	local “small” species of *Trapa*	need to clarify	difficult to distinguish local forms
	Elatine orthosperma Düben	3b	
	Eleocharis starczenkoae A. E. Kozhevnikov	3a	
	Schoenoplectiella hotarui (Ohwi) J. Jung et H. K. Choi	3d	
	S. komarovii (Roshev.) J. Jung et H. K. Choi	3d	
	S. lineolatus (Franch. et Savat.) J. Jung et H. K. Choi	3d	
	Schoenoplectus triqueter (L.) Palla	3d	
24. Amur Region	*Trapa natans* L. s.l.	exclude	
	Trapella sinensis Oliv.	2a	instead 3d
	Potamogeton juzepczukii P.	2a	endemic

	Dorof. et Tzvel.		
25. Jewish Autonomous Region	local “small” species of *Trapa*	need to clarify	difficult to distinguish local forms
26. Primorie Territory	*Aldrovanda vesiculosa* L. *Potamogeton juzepczukii* P. Dorof. et Tzvel.	4 2a	instead EN endemic
27. Sakhalin Region			no additions

Note. Regions where the number of protected species of aquatic plants is atypically low are indicated in bold.

* In The Plant List *Z. repens* Boenn. is treated as a form of *Z. palustris* L. s.l.

Figure 1. Regions of Asian Russia and numbers of aquatic vascular plants included in regional Red Data Books (number of region / number of species).
Numbers of regions and numbers of species in accordance with Tables 1, 3.

See attached file.

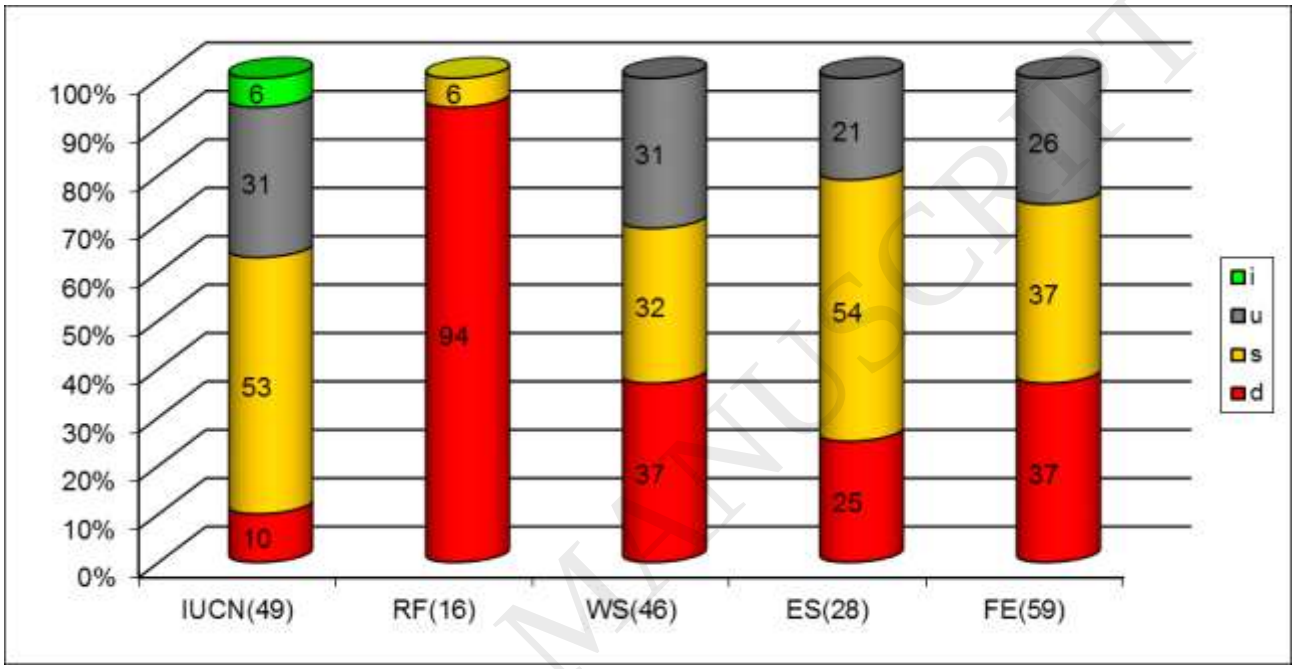

Figure 2. Population trends of protected aquatic vascular plants in the IUCN, Russian and Asian Russian regional Red Lists.
IUCN – IUCN Red List, RF – Russian Federation, WS – West Siberia, ES – East Siberia, FE – Far East; in brackets a number of species. Population trend: d – decrease, i – increase, s – stable, u – unknown.